SECTION 87

ELECTRICAL SYSTEMS GENERAL REQUIREMENTS

87.1 REFERENCES

(87A) WASHINGTON STATE FERRIES, *Vessel Design Standards for Drawings Using AUTOCAD (latest version)*

(87B) USCG NVIC 2-89, *Guide for Electrical Installations on Merchant Vessels and Mobile Offshore Drilling Units*

(87C) IEEE STD 519, *IEEE Guide for Harmonic Control and Reactive Compensation of Static Power Converters*

(87D) Code of Federal Regulations - 46 CFR Sub-chapter H

(87E) Code of Federal Regulations - 46 CFR Sub-chapter J

(87F) IEEE Std 45, *Recommended Practice for Electrical Installations on Shipboard* (latest edition)

(87G) IEEE Std 1202, *Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies* (latest edition)

(87H) IEEE Std 1580, *Recommended Practice for Marine Cable for Use on Shipboard and Fixed or Floating Marine Platforms* (latest edition)

(87I) IEC Std 60228, *Conductors of Insulated Cables* (latest edition)

(87J) IEC Std 60332, *Tests on Electric Cables Under Fire Conditions – Part 3-22: Test for Vertical Flame Spread of Vertically-Mounted Bunched Wires or Cables – Category A* (latest edition)

(87K) IEC Std 60754-1, *Test on Gases Evolved During Combustion of Materials from Cables – Part 1: Determination of the Amount of Halogen Acid Gas* (latest edition)

(87L) IEC Std 60754-2, *Test on Gases Evolved During Combustion of Electric Cables – Part 2: Determination of Degree of Acidity of Gases Evolved During the Combustion of Materials Taken from Electric Cables by Measuring pH and Conductivity* (latest edition)

(87M) IEC Std 61034-1, *Measurement of Smoke Density of Cables Burning Under Defined Conditions – Part 1: Test Apparatus* (latest edition)

(87N) IEC Std 61034-2, *Measurement of Smoke Density of Cables Burning Under Defined Conditions – Part 2: Test Procedure and Requirements* (latest edition)

87.2 INTRODUCTION

This Section contains the Contractor Design and Provide general requirements for the Ship's Service electric plant. This Section and the supporting Sections that follow provide requirements for Ship's Service power generation, distribution, conversion and consuming equipment. The intent of this Technical Specification is to describe a complete, modern electrical plant using commercial marine equipment.

See Section 50 of the Technical Specification for general requirements regarding the configuration of the machinery plant.

In addition to the applicable rules and regulations stated elsewhere, the recommendations of References (87B), (87C), and (87F) shall be requirements of this Technical Specification.

For WSF Fleet-wide Standardization purposes, End No. 1 of the Vessel shall always be considered the bow, and this designation shall delineate port and starboard, fore and aft wherever they are addressed in the Technical Specification.

87.3 GENERAL

Unless otherwise directed by the Technical Specification, all Contractor equipment and material provided shall be new, suitable for marine use and shall be approved or listed by the USCG, as required by law, rule, or regulation for the intended service.

Design and provide cables, wiring, hangers, connectors, terminal lugs, junction boxes and other items and devices required to install the Owner Furnished Equipment (OFE) supplied by the Propulsion System Integration (PSI) Contractor. The OFE equipment, which includes Main Propulsion and AMS systems, shall be installed in accordance with the PSI Contractor's requirements and technical information, and this Technical Specification, to make it a complete, functional, and fully operational common AC electric power system to supply Ship's Service power.

The Ship's Service electric power is normally provided by the Ship's Service Diesel Generators at 480 Vac, 3-phase, 3-wire delta-connected, 60 Hz. An Emergency Diesel

Generator also supplies ship's emergency electrical power at 480 Vac, 3-phase, 3-wire, 60 Hz upon loss of normal power. Phase rotation shall be A-B-C.

The Ship's Service power and lighting distribution systems shall be as described in Sections 90 through 92 of the Technical Specification.

The electrical systems shall meet the requirements of References (87D), (87E), and (87F), in effect on the date of bid opening. Equipment and components shall be located by the Contractor in such a manner as to most readily facilitate operation, and allow for ease of maintenance.

NOTE: Contractor shall be wholly responsible for ensuring that the loads are uniformly distributed and balanced within the distribution panels; for ensuring that the design and installation of electrical circuits and systems complies with the requirements of Reference (87E), other cognizant regulatory documents and Authoritative Agencies and the Technical Specification; and that circuits and systems are in every respect safe, complete, functional, and fully operational at the time the Vessel is delivered to WSF.

Work on components and equipment specified elsewhere in the Specification may require that electrical service be incorporated in working drawings during their development and reflected in the Final As-Built drawings. The Contractor shall rely on certified vendor drawings when provided. Identification and inclusion of the additional items are solely the Contractor's responsibility.

The Contractor shall exercise caution in selecting electrical and electronic devices to be installed in the Vessel, and shall select equipment inherently immune to electrical noise or shall provide power line conditioning for susceptible devices.

Separate power and lighting cables from control, indicator, alarm, and communications (except as noted) cables as much as possible. In general, separation shall not be less than twelve (12) inches. Low voltage wireways utilizing their own segregated bulkhead/deck penetrations that contain cables with impressed voltages of 50 Vac, or 50 Vdc or less shall be developed. Cat 5e cable minimum separation shall be as follows:

1. Twelve (12) inch separation minimum for data cables and power cables.

2. Forty-eight (48) inch separation minimum for data cables and motors and transformers.

3. Five (5) inch separation minimum for data cables and fluorescent light fixtures (their ballasts).

All cables used in control, indicator, alarm, and communications circuits and systems shall be shielded type, unless the equipment is by design inherently immune to harmonics, spikes and electric noise induced from adjacent cables or external sources.

Provide conductor shields for control, indicator, and alarm circuits and systems within motor starters and within other enclosures containing power and lighting circuits.

Provide copper braided shielded power cables between variable frequency drives and the motors they control.

Nameplates, labels and operating instruction placards shall be furnished and installed for all systems. See Section 24 of the Technical Specification.

The Contractor is advised that he is wholly responsible to verify all cable, wire, and component location measurements before proceeding with the Work.

Lighting fixtures, receptacles, motor controllers and power panels shall be located to facilitate operation, allow for ease of maintenance and not restrict passageways and ladders. Doors, or other accesses, for all panels, controllers, and other similar items and devices shall be capable of opening a minimum 90 degrees for maintenance or repair.

The Contractor shall be responsible for ensuring that adequate ventilation is provided to cool electrical equipment.

Equipment shall operate such that when power is interrupted and restored, no damage will result to any component or part of the equipment.

All electrical equipment shall be protected or shielded to prevent the equipment from being damaged by exposure to oil, water, or excessive heat. The equipment is to be flush mounted when installed in sheathing and decorative ceilings and the electric cables shall be concealed. Removable access panels shall be provided over main cableways to all power panels.

Electric machinery, equipment and wiring shall be located to ensure adequate natural cooling to avoid exceeding rated temperatures. Equipment designed on the basis of the standard 40C degrees or 50C degrees (in the machinery spaces and the Emergency Diesel Generator Room only) ambient temperatures shall require no special design considerations for short duration shut-down of ventilation systems.

Electric wiring and equipment shall be installed in areas where maintenance can be accomplished without removing a portion of the deck.

Power consuming equipment shall operate as specified with a steady state voltage tolerance of plus or minus 5-percent (± 5%) when measuring the average of the three(3) line-to-line voltages, and plus or minus 7-percent (± 7%) for any one line-to-line voltage, and with a frequency tolerance of plus or minus 3-percent (±3%). Temporary voltage dips or frequency excursions during motor starting or Vessel maneuvering shall not cause damage or interruption of service to equipment.

87.4 VOLTAGE AND FREQUENCY RATINGS

Electric machinery and equipment shall be selected for the highest operating efficiency that is commensurate with reliability, maintainability, duty cycle and requirements of minimum size and weight.

87.4.1 Electrical Power Equipment Selection

Unless otherwise specified, electric power consuming equipment shall be selected to have a frequency rating of 60 Hz and one (1) of the following nominal voltage/phase ratings:

A. 480-Volt, three-phase

B. 208-Volt, single- or three-phase

C. 120-Volt, single- or three-phase

87.4.2 DC Power Consuming Equipment Voltage Ratings

Unless otherwise specified, direct current power consuming equipment shall be selected to have a voltage rating 24 Vdc or 12 Vdc.

87.5 HARMONIC INTERFERENCE

Equipment suppliers of variable speed drives shall provide filtering circuits or equivalent to minimize the effect of induced harmonics.

The harmonic distortion level shall be maintained to be less than 5-percent (<5%) **T**otal **H**armonic **D**istortion (THD) and shall be verified by the Contractor by an analysis of the electrical system. This analysis shall include the influence of the above named equipment while operating at the worst case condition. The Contractor shall be responsible to add filtering, if necessary, to insure that the 5-percent (5%) THD is not exceeded.

87.6 REQUIRED DRAWINGS

The Contractor shall prepare all Working Drawings, calculations, and analyses set forth in the *PHASE III DETAIL DESIGN AND CONSTRUCTION REQUIREMENTS*, and Section 100 of the Technical Specification as part of the Contract. These drawings shall be updated to Final As-Built drawings as set forth in this Section and Section 100 of the Technical Specification.

The Contractor shall prepare Working Drawings for all electrical and interior communications systems installed in the Vessel. At a minimum, all system drawings shall have wiring plans plus a material list. The wiring diagram shall identify all cables and wiring, including wiring floaters as described in the *CABLE INSTALLATION* Subsection in this Section of the Technical Specification. These drawings shall be prepared as specified in this Section, Reference (87A), and Section 100 of the Technical Specification.

The Final As-Built One-Line Diagram, and other electrical drawings, shall accurately identify each cable type and designation.

87.7 DRAWING PREPARATION

Phase II and Phase III calculations and drawings are for this Contract considered Working Drawings and they shall be corrected, updated and delivered as Final As-Built drawings as set forth in Section 100 of the Technical Specification. Initial submittal for WSF review shall be made prior to the purchase of any Contractor provided electrical generation equipment, electrical distribution equipment, or cabling. WSF approval of these drawings shall be obtained prior to the installation of any cable.

For ease of tracking, all distribution panels shall be rated at a minimum of 225 Amp. Feeders to distribution panels need not be sized for 225 Amp, but sized appropriately according to the design load.

Power and lighting distribution panels shall have 20-percent (20%) minimum of the total number of poles remaining unused **at the time of Vessel delivery** to WSF. Provide loose, one (1) spare circuit breaker of each rating for each distribution panel.

Power and lighting distribution panels shall be increased in size as necessary to maintain 20-percent (20%) spares capacity as new loads are added, until the 42-pole maximum is reached. In locations where mounting height/space is limited, such as beneath Pilothouse windows, 30-pole panels shall be utilized that sub-feed to additional panel(s) until the loads are accommodated. Upon reaching the maximum panel size, every attempt shall be made to relocate loads to other panels, if practical, before the number of spare circuits is reduced below 20-percent (20%). Requests for consideration of changes to the 20-percent (20%)

spare requirement shall be made to, and written approval obtained from, the WSF Representative.

The Contractor shall develop and employ a method for estimating cable lengths, to be used in performing the required engineering calculations, which will ensure estimated cable lengths are within the following percentage of the actual installed lengths:

0 feet to 30 feet	-	30-percent (30%)
30 feet to 100 feet	-	20-percent (20%)
over 100 feet	-	10-percent (10%)

For cable, other than MIL-C-24643, meeting the specifications of the *Cable Type* Subsection in this Section of the Technical Specification, the Feet Markings on the cable jacket shall be used for determining actual cable length. The feet marking at each end of the cable shall be recorded and the difference between the two numbers shall be recorded as the actual cable length. Provide the WSF Representative with a table showing the actual length of each cable installed.

The Contractor shall take care to use the estimated and measured lengths in a consistent manner in all of the required engineering calculations. Should the WSF Representative determine that the estimated lengths used in performing the required engineering calculations are not within the required percentage of the actual installed length, the Contractor may be required to recalculate and resubmit all the engineering calculations which may have been affected, and update all drawings that have been affected by the use of erroneous cable lengths.

The Contractor shall be totally responsible for the expense associated with any required recalculations and the full expense of replacing any cable(s) which prove to be inadequate as a result of erroneous calculations.

Provide all data files and documentation to the WSF Representative when submitting the engineering calculations for review. All data files shall become the property of WSF at the completion of the Work.

If a user written (non-commercial) computer program is used in the preparation or presentation of the required engineering calculations, the program, source code, data files and legal issues of any commercial programs used in developing or running that software, and its license, shall be provided. The program shall be sufficiently documented so that the WSF Representatives will be able to fully understand the program, be able to modify input data and run the program at a later date.

If a spreadsheet is utilized for doing voltage drop, phase balancing, or other required engineering calculations, the cells shall contain the formula for generating the results using input data provided for cable type, cable length, and individual loads in amperes. Derived values and totals shall be automatically updated whenever any of the input data is changed and shall not require manual updating of intermediate data. The spreadsheet shall have the characteristics of an interactive spreadsheet with related data base and shall not be merely a table of data.

If a data table is supplied it shall be accompanied by a separate booklet containing all the calculations used to derive tabulated values.

For WSF Fleet-wide Standardization purposes the Contractor shall provide a model of the Vessel's Electrical Distribution System prepared using the DAPPER Program (Revision 5.0.3.1 (or later)), developed by SKM Systems Analysis commercial software package for all of the calculations. The above deliverable is one of the options available in the DAPPER Suite of Programs.

Design, prepare, and provide all electrical drawings, utilizing AutoCAD®, Release 2005 format and the requirements set forth in this Section and Section 100 of the Technical Specification. Drawings shall be continually updated and modified as necessary during the course of the Work in order that FINAL AS-BUILT drawings are available as required by Section 100 of the Technical Specification. If a drawing preparation system other than AutoCAD®, Release 2005 is employed, it shall be convertible to AutoCAD®, Release 2005 at the time of presentation. See Section 100 of the Technical Specification for additional drawing preparation requirements.

In addition to the submittal of FINAL AS-BUILT drawings, deliver to the WSF Representative all Contractor generated electrical drawings, on WINDOWS compatible CD-ROM or DVD-ROM electronic media copy, in AutoCAD®, Release 2005 format.

The WSF Representative will provide Title Blocks and Drawing Sheets in magnetic or CD-ROM format to be used in preparation of the electrical drawings. The WSF Representative will also provide the most recent version of Reference (87A) that forms a part of this Contract.

All Contractor prepared and AS-BUILT Drawings shall be drawn in compliance with Reference (87A). Any drawing submitted to WSF that is found not to be in full compliance with this standard will be Rejected and returned to the Contractor without further review.

All drawing dimensions shall be in conventional English inch units of measurement. Dimensions over 72 inches shall be in <u>feet</u> **and** <u>inches</u>, dimensions 72 inches and less shall

be shown in inches only. Fractional inches may be shown in either architectural (2¼) or engineering (2.25) format but the same system shall be used consistently throughout the drawing. If desired for clarity, the drawing may show metric measurements enclosed in brackets in addition to the English dimensions required above. If this method is employed, both scales used and the units of measure shall be indicated.

NOTE: Because electrical system plans are highly interactive, WSF will not grant final review of the One-Line Diagram, power and lighting deck plans, phase balancing and panel schedule, voltage drop calculations, fault current analysis, and coordinated trip analysis until all of the drawings have been submitted for review, and until all necessary information and supporting documentation has been made available for review by the WSF Representative.

While it will not be possible for the WSF Representative to give final review of the drawings listed above until they have been submitted as a complete set that displays consistent information from one drawing to another, the WSF Representative will review drawings submitted prior to that point for format, methodology, and accuracy based on the information displayed. Drawings will be returned to the Contractor with comment and, if appropriate, reviewed subject to final coordination with other core electrical drawings. The above listed drawings may be reviewed for general content, format, and design features, but final review may be withheld until all necessary information and supporting documentation is available for review by the WSF Representative.

The Contractor shall inform the WSF Representative, in writing, when the above listed drawings are complete and have been coordinated with one another, and are ready for review as a **complete** electrical drawing package.

Interior communications drawings and other electrical drawings of a "stand alone" nature, (i.e., motor controller wiring and schematic diagrams, switchboard arrangements, and interior communications system drawings, will be reviewed on an individual basis).

87.7.1 Voltage Drop Calculations

The Contractor is wholly responsible for assuring that cable sizes are correct prior to procurement and installation. The cable sizes shall be adjusted as necessary to assure that the maximum percentage voltage drop from the Ship's Service Switchboard distribution section to the furthest distribution panel does not exceed 2-percent (≤2%), that the maximum percentage voltage drop from the Ship's Service Switchboard to the furthest load does not exceed 5-percent (≤5%), and that the available fault current at all loads is sufficient to assure proper clearing of circuit breakers and protection of installed cables against prolonged overcurrent as a result of insufficient circuit breaker clearing

currents. No allowance for voltage drop correction shall be made for transformer voltage adjusting taps.

On direct current systems, size battery capacity and cable selection to ensure that the voltage drop to the furthest load from the battery bank does not exceed 5-percent (≤5%).

In calculating voltage drop upstream of the final load, the full amperage of all downstream loads must be taken into account at their full individual load values. When calculating voltage drop to distribution panels or load centers, the amperage value used shall be the total of all connected circuits at their full load value plus an allowance for spare circuits as described below. The amperage of the loads used in the voltage drop calculations shall normally be based on the values given on the manufacturer's nameplate or catalog specification sheet for the device or load under consideration. If the load is stated in Watts or kilowatts, the amperage shall be calculated based on the nominal voltage of the circuit. Corrections for power factor and efficiency shall be applied if known.

In all cases, the voltage drop calculations based on the above conditions shall be the only method of determining voltage drop acceptable to WSF. Actual measurement of the voltage drop using empirical measurement methods shall not be an acceptable substitute for the calculation methods described herein.

Voltage drop calculations shall be accompanied by a simplified one-line diagram showing at a minimum: cable designations, cable types, cable lengths; voltage drop of each conductor, composite voltage drop at each panel and at the final load; amperage in each conductor, load per phase of each panel, transformer, transfer switch and switchboard. Spare circuits shall be accounted for in the voltage drop calculation by assigning a load equal to the average load of the active poles in each panel, to each spare pole in the panel. (See detailed requirements below).

When calculating voltage drops, the Contractor shall allow for future spares loading. The allowance shall be based on a per spare allowance of a load equal to the sum of the phase loads on the panel divided by the number of active phase loads installed in the panel. The sum of the phase loads shall be defined as the sum of all loads on the panel which are connected at the time of delivery of the Vessel to WSF. For example, three-phase circuits shall have amperage values on all three-phases, single-phase 208 Vac circuits shall have amperages on two-phases, and single-phase 120 Vac circuits shall have amperages on the "hot" phase only. The values thus described shall be added together and divided by the total number of active poles. The total number of active poles shall be defined as the total number of poles installed to which loads are connected less the number of switched neutral poles.

87.7.2 Power Panel and Phase Balancing

Power panels and switchboards feeding loads at 480 Volts shall have the loads distributed to balance the phases to within a 10-percent (10%) deviation from the average value of the three phases. This is not normally a problem as the majority of 480 Volt loads are three-phase. However, when loads are single-phase and not evenly balance on all three phases, the Contractor shall assign circuit breakers within the panel, load center, or switchboard to best balance the three phases.

Power panels rated at 208Y/120 Vac serving 208 Volt and 120 Volt single-phase loads shall have the loads distributed to balance the phases to within a 15-percent (15%) deviation from the average value of the three (3) phases. A deviation of 25-percent (25%) from the average value of the three phases will be permitted for panels which have an average load of less than 25 amperes per phase. The use of spare circuits to balance a panel **is not acceptable** to WSF.

For receptacle circuits in the Women's, Men's, and Unisex Restroom spaces, use values in accordance with Reference (87F).

The power panel schedule shall show each switchboard, load center, and distribution panel on a separate sheet of the report. Information on each sheet shall include the panel designation, panel's physical location, panel model or class number, bus bar ampacity, panel voltage rating, number of phases, short circuit rating, number of poles or physical mounting space as appropriate, and actual voltage and number of phases provided. The individual sheets shall also show total amps per phase, average phase amps and percentage deviation from the average of each phase.

The Contractor shall be responsible to arrange and balance circuits within each panel, assigning panel circuit location and circuit numbers during the process.

87.7.3 Fault Current Analysis

The required fault current and coordinated trip analyses shall be prepared utilizing the DAPPER Program (Revision 5.0.3.1 (or later)) and shall be accompanied by a simplified One-Line Diagram showing cable designations, cable types, cable lengths, fault analysis points, motor load contributions, and cable impedance of all cable types used.

Fault current calculations shall be performed at all power and lighting distribution panels to demonstrate maximum fault current conditions and to verify the panel and circuit breaker withstand and current breaking capacities are adequate. In addition fault current calculations shall be performed on at least one (1) circuit on each panel (the one having

the longest electrical length - i.e., circuit impedance) to demonstrate minimum fault current capacities to clear circuit breakers. These calculations shall include the entire cable length to the furthest load. When the minimum fault currents are less than the instantaneous trip ratings of the installed protective device, the Contractor shall demonstrate that the cable is adequately protected from long term over current conditions. On panels where inadequate fault current is available on the longest circuit as described above, additional fault current calculations shall be made on all branch circuits in that panel in order to identify all potential problem circuits. Cable sizes to final loads shall be adjusted as necessary to correct minimum fault current problems.

87.7.4 Circuit Breaker Coordination Study

The required Circuit Breaker Coordination Study shall be prepared utilizing the DAPPER/CAPTOR Program (Revision 5.0.3.1 (or later)) and shall be accompanied by a simplified one-line diagram showing the combinations of breakers shown in the coordination study. This diagram may be combined with that provided with the fault current analysis.

The Contractor shall demonstrate all combinations of circuit breaker coordination possible and bring to WSF's attention any areas of marginal or non-coordination. The Contractor shall be responsible for necessary modifications to the design and installation to correct unacceptable coordination situations.

87.8 ELECTRICAL LOAD ANALYSIS

An Electrical Load Analysis shall be provided which describes various electrical loads associated with Vessel operating conditions. The loads shall be categorized into a format suitable for demonstrating the number of generators and the generator ratings required for both Ship's Service and Emergency Service, the sizing of transformers, and load distribution centers. The operating modes shall include, as a minimum, those defined as follows:

A. Cruise - Winter and Summer conditions

B. Maneuver

C. Emergency

D. Shore Power

Cruise Mode applies to normal transit conditions at the service speed defined in Section 1 of the Technical Specification.

The Maneuver Mode is similar to the Cruise Mode but includes maneuvering in restricted waters.

Emergency conditions apply when normal power is lost.

Shore Power shall be used to determine the maximum night tie up loads that can be supported based on a 150 Amp Shore Power availability under which normal tie-up functions can be maintained on the Vessel.

The Load Analysis shall be prepared using only true loads. No allowance for spare circuits shall be included in the analysis, but allowances shall be made for receptacles where permanent loads such as vending machines are normally connected. For receptacles located in the Women's and Men's Restrooms, and Unisex Restroom spaces, follow the requirements of Reference (87F).

With the exception of the Emergency condition, the Load Factors used in the preparation of the Load Analysis shall be time diversity factors. In most cases involving lighting and resistive loads the load factor shall be unity (1). The time diversity load factor is based on the percentage of time the load is actually operating in a given load analysis condition. If lighting is always "ON" it shall be rated at 1.0, but a motor that only functions part time (i.e., a refrigeration compressor) shall have a correspondingly lesser value assigned. For the Emergency condition, load values are the connected load.

The Load Analysis shall summarize all power sources available to the Vessel, the expected loads when each of the sources is providing power, an analysis of any operating limitations imposed by a power source, and a statement of the ability of the various power sources to adequately provide power under various operating conditions. The Load Analysis shall determine any requirements for Load Shedding on loss of either one of the running generators when operating in parallel. In general, one (1) generator’s capacity of load shall be shed in steps, so that the loads connected to the bus are within the capability of the remaining machine. Loads to be shed shall be non-vital loads such as Food Vending areas or HVAC loads. Final determination shall be done in consultation with the WSF Representative.

After the required Load Analysis has been completed and the Vessel's normal operating load determined, the Contractor shall perform a calculation of voltage dip which can be anticipated when starting any of three largest motor loads on each of the available sources of power. The initial conditions for the voltage dip calculations shall include the full normal electrical load with two of the largest connected motors running. Any conditions which may limit the starting of the motors shall be noted in a written report. The calculated voltage dip and recovery for each of the three (3) largest connected motor loads to each power source shall be clearly identified in the report. The final Load Analysis shall be a computer based

report that is easily understandable and maintainable in the future. Complete documentation, including the software source code (if not a commercial program), and the compiler if the program is compiled, shall be provided. All programs and documentation shall be submitted on Windows compatible CD-ROM or DVD-ROM electronic media copy.

For WSF Fleet-wide Standardization purposes the final Load Analysis shall be a computer based report using Microsoft® Excel 2000 in a DAPPER Suite of Programs (Revision 5.0.3.1 (or later)) model format. WSF will provide a Model Design Load Analysis in the DAPPER format on CD-ROM upon written request from the Contractor. The Model Design Load Analysis is offered for "*information only*" and WSF makes no representation as to its reliability, accuracy or currency.

87.9 MATERIAL & EQUIPMENT

Intermittent voltage and frequency transients and excursions shall not cause damage to, or interruption of, service to equipment.

Unless otherwise specified, all ferrous components of equipment shall have a corrosion resistant finish of zinc, cadmium, or electrostatically applied paint.

Equipment requiring external wiring shall have terminal boards or blocks with solderless wire terminations to which all connections shall be made. All cable terminations connected to PHOENIX CONTACTS terminal blocks, or equal, shall be of the compression type and shall be one of the following varieties, dependent upon the design of the terminal strip or terminal block:

1. UKK 5-TG – terminal blocks, color-coded; "RED" - 480 Vac, "YELLOW" - PLC, "GRAY" - all DC Voltages, "WHITE" - 120 to 240 Vac.

2. ST-SILA 250 UK4 –120 Vac fuse holders with blown fuse light emitting diodes (LEDs).

3. SLKK 5 – jumpers.

4. 35 mm perforated DIN rail.

5. ZB 6 – label marking system with embossed "BLACK" letters on "WHITE" 6.2 mm labels.

All wiring terminations shall be made to terminal boards using ring or wire compression caps under compression terminal connections. No terminations shall be made using bare wire end. **Spade and fork wire termination will not be acceptable**. No more than two (2) wire

terminations shall be placed under each screw of a terminal board exclusive of manufacturer supplied jumpers. For WSF Fleet-wide Standardization purposes, pin type terminal blocks shall be PHOENIX end thimble type sleeves, suitably sized for the conductor. Bare wire **shall not** be installed on any terminal strip without wire terminations installed on the wire.

All termination insulation shall be soft vinyl. Hard plastic insulating sleeves shall not be used. **All termination lugs shall be installed using a manufacturer's approved controlled-cycle crimping device**.

Unless otherwise specified, enclosures for all electrical equipment shall be as follows:

1. NEMA 4X, stainless steel or fiberglass enclosures shall be used in all locations exposed to weather, including the entire Vehicle Deck, whether under the Passenger Deck or not, and in other locations that are normally considered to be "wet or damp spaces". A damp space is any space where water vapor can reasonably be expected to condense on equipment in the space (i.e. a Sun Deck open air Passenger Lounge will fall into this category).

2. NEMA 12 shall be used in all dry locations below the Lower Vehicle Deck, on the interior of the Machinery Casing, in fan rooms or other spaces which functionally serve as outside air plenums, and the Emergency Diesel Generator Room.

3. NEMA 1 with drip shield shall be used in all other interior locations on the Passenger Deck and above, except for flush mounted enclosures installed in decorative paneling. Knockouts shall not be permitted in any enclosure.

4. NEMA 2 shall be used in all interior locations on the Passenger Deck or above which are mounted in decorative panels or above false ceilings. Knockouts shall not be permitted in these enclosures.

5. Receptacle boxes and small J-boxes shall be copper-free aluminum or brass.

In weather locations, including the entire Upper and Lower Vehicle Deck areas, Picklefork and Sun Deck open air lounge areas, and in all wet locations, all connections shall be made through connection boxes fitted with appropriately sized packing glands. Except under unique and specific conditions, and only with the written approval of the WSF Representative, packing glands shall be installed in the bottom of the enclosure.

See Sections 90 and 92 of the Technical Specification for additional requirements.

87.10 EQUIPMENT IDENTIFICATION

Design and provide identifying label plates as specified and in accordance with Section 24 of the Technical Specification on all electrical equipment whose function is not readily apparent. Include any special precautions, maintenance, or operating instructions on the label plates, or on a separate plate attached elsewhere on the equipment.

Clearly label any enclosure or piece of equipment which receives power from multiple sources. The label shall list all sources of power and the voltages present. See Section 24 of the Technical Specification.

Distribution panels shall have nameplates in accordance with Sections 24 and 90 of the Technical Specification.

87.11 EQUIPMENT INSTALLATION

The Contractor shall provide all labor, materials, foundations, and equipment to dielectrically, and vibration isolate all Shipyard furnished and OFE equipment to:

1. Electrical equipment shall, at a minimum, meet isolation requirements of the manufacturer for all equipment installed by the Technical Specification. Equipment shall include, but not be limited to, all switchboards, transformers, controllers, consoles, battery chargers, electrical panels, MCC cabinets, control panels, and remote control panels.

2. The methodology presented in WSF Drawing. No. 8403-6068-002-01 - MISC. FDNS FOR PROPULSION CONTROL SYSTEM INSTALLATION represents an acceptable means to vibration isolate equipment.

3. All equipment shall be provide with an installation to meet those forces as set forth in the *MATERIALS AND WORKMANSHIP* Subsection in Section 1 of the Technical Specification. All equipment that is of a tall or top heavy (high center of gravity) natural that would be susceptible to tipping during a collision shall be provided with suitable bracing from the equipment to main structure to prevent the equipment from tipping over or tearing loose. All such bracing shall be identified and approved by the WSF Representative.

87.11.1 Electrical Grounding and Bonding

All electrical enclosures and/or equipment manufactured for electrically conductive material shall be electrically bonded (grounded) to the Vessel structure as follows:

1. Bonding shall be achieved through the method of mounting equipment, or by use of flexible copper cable or strap. Either method shall form a positive ground connection from the enclosure to the Vessel structure;

2. Bonding cables shall be installed using minimum length of cable and be consistent with, and meet Authoritative Agency requirements;

3. All bonding cables shall be installed in locations that provide minimum exposure to possible physical damage and provide inspection, repair and replacement access. Bonding cables shall be attached to Vessel structure by a dedicated weld stud or weld pad and shall not be attached to pipe hangers, wireways, mounting hardware, or attachments. Only one (1) bonding cable per attachment shall be installed.

4. The Contractor shall closely follow the manufacturers' instruction for grounding of the shafting and rudder post, and as specified by all other manufactures of OFE and/or Contractor provided equipment.

5. Bonded equipment shall include, but is not limited to, distribution panels, switchboards, generators/alternators, motor control centers, electric hot water heaters, transformers, electronics cabinets, battery chargers, transfer switches, individual motor controllers and motor frames, lighting fixtures, and receptacles. Electrical devices isolated by nonconductive bushings, boots, vibration isolators, and dampers shall also be bonded (grounded) to the hull. All equipment capable of generating static discharges shall also be bonded to the hull. (See Section 92 of the Technical Specification requirements as to grounding of fluorescent and incandescent lighting fixtures, receptacle, and light switches).

6. Provide grounding systems complying with 46 CFR §111 and the codes and ordinances specified.

87.11.2 Resilient Mounting of Equipment

Provide resilient mounts for all equipment, whether Contractor provided or OFE, which require such mounting, as set forth by the manufacturer. All mounts shall also provide the strength and stiffness required to support, and maintain alignment of mounted equipment in its operational mode.

All Contractor provided and OFE equipment susceptible to, or producing vibration shall be fitted with vibration isolating mounts. All cabinets containing electronic components shall be resiliently mounted regardless of the manufactures' recommendations.

87.12 CABLE INSTALLATION

87.12.1 General

Design and provide a complete Ship's Service and Emergency Electrical Power Generation and Distribution systems, including all cable, connectors, hangers, wireways, terminals, junction boxes, switches, disconnects, distribution panels, motor control centers and controllers, and other similar items and devices required to produce an electrical system which complies with the intent of the Technical Specification, the requirements of the USCG and other cognizant Authoritative Agencies, and is in keeping with Passenger Vessel marine industry practices.

See the *GENERAL* Subsection in this Section of the Technical Specification for cable separation requirements.

87.12.2 Cable Type

All cable and electrical wiring election, application and installation shall follow the specifications for cables set forth in this Section and Section 90 of the Technical Specification. No cable or wiring shall contain any asbestos. The Contractor shall use MIL-C-24643, Low Smoke cable, or Shipboard Power and Control Cable meeting the requirements as outlined in References (87D) through (87N) and the design specifications described below. The cable used shall be ABS approved and be acceptable to the USCG. The WSF Representative will consider no other commercial cables. All cable shall be unarmored unless approved otherwise by the WSF Representative. All new power cable's ampacities shall be designated for operating in a 50C degrees ambient environment and then de-rated to 80-percent (80%) of rated ampacity. Additional de-rating shall be done as required by the Contractor for the particular installation. See Section 90 of the Technical Specification for other cable requirements.

If cables other than MIL-C-24643, Low Smoke are used, they must meet the following design specifications:

87.12.2.1 Design – General

Cables shall be designed and manufactured to comply with the construction requirements of IEEE Std 1580-2001.

Cables shall be Low Smoke, Halogen Free (LSZH). Emissions of acid and corrosive gas, under fire conditions, shall comply with the requirements of IEC

60754-1 & 2. The smoke emission test shall comply with the requirements of IEC 61034-1 & 2.

Cables shall be Flame Retardant, complying with the requirements of IEC 60332-3 (Category A) and IEEE 1202.

Power Cables shall have a voltage rating of at least 1000 volts phase-to-phase and at least 600 volts phase-to-ground.

Control Cable shall have a voltage rating of at least 300 volts.

Cables shall be rated for continuous operation of –45C degrees to +90C degrees.

Conductors for Power Cables shall be color coded as follows:

a) 2-conductor: "RED", "BLACK"

b) 3-conductor: "RED", "WHITE", "BLACK"

c) 4-conductor: "RED", "WHITE", "BLACK", "GREEN"

Conductors for Multi-Conductor Control Cables shall be color coded as follows:

a) 6-conductor or greater: "WHITE" with "BLACK" number printing in accordance with IEEE Std 45 and IEEE Std 1580-2001.

Conductors for Control Cable shall be color coded as follows:

a) "WHITE" and "BLACK" conductors with number printing:

ONE 1/ONE 1, TWO 2/TWO 2, etc.

A durable printing or embossing on the cable jacket shall provide cable identification. Marker material shall be suitable for its service. Marking shall give the following information at intervals not exceeding three (3) feet:

a) Manufacturer.

b) Cable designation (see IEEE Std 1580-2001 Section 5.19).

c) Voltage Rating.

d) The listing (or classification) mark of an independent product testing and certification organization.

e) Application specification and the year of the standard (e.g., IEEE Std 1580-2001).

f) Feet markings every three (3) feet indicating the remaining length of cable on the spool.

Jacket material shall be resistant to the following:

a) Lubricating Oil, Diesel Fuel, Gasoline, Hydraulic Oil, Acid, Sea Water, Ozone, and UV Radiation.

87.12.2.2 Design – Construction

Conductors shall be finely stranded (Class 5 & 6), high conductivity, non-compacted, soft annealed copper per the requirements of IEC 60228.

Conductor strands shall be 0.20 mm or 0.30 mm in diameter.

Conductor stranding shall be of uniform, concentric lay formation consisting of a number of individual circular bunches laid up together in a helical 'SZ' configuration.

Insulation material shall be Cross-Linked, Thermoset, Polymer, IEEE Std 1580-2001 Type LSX, having an Oxygen Index of greater than 32 and HCL emission of less than 5-percent (<5%).

Insulation material shall have a minimum (unaged) tensile strength of no less than 10.3 N/mm² and a minimum elongation at rupture of 150-percent (150%).

Jacket material shall be Cross-Linked, Thermoset, Polymer, IEEE Std 1580-2001 Type L (XLPO) and pressure extruded to eliminate air cavities between core interstices.

Jacket material shall have a minimum (un-aged) tensile strength of no less than 8.9 N/mm² and a minimum elongation at rupture of 160-percent (160%).

The temperature rating of the jacket shall be no less than 15C degrees lower than the temperature rating of the insulation.

87.12.2.3 Additional Requirements for Control Cable

The shielding shall consist of either polyester/aluminum tape applied helically with a minimum overlap of 25-percent (≥25%) or a bare or coated copper braid. Where a polyester/aluminum tape shield is used, a coated copper, stranded drain wire shall be applied in contact with the aluminum side.

A tinned annealed copper drain wire no smaller than 0.5 mm^2, or no smaller than two (2) gauge sizes less than the instrumentation or signal circuit conductor size (whichever is larger) shall be used.

Where a braided coated or bare copper shield is used, it shall be constructed using a minimum of 34 AWG wire.

All common cable sizes and types used by the Contractor shall be stocked in sufficient quantity by the cable manufacturer, for at least the length of time of the Contract, in a dry, heated location within a fifty (50) mile radius of Colman Dock, Pier 52, Seattle, WA and be available to the Contractor within twenty-four (24) hours of submitting an order to the cable manufacturer. The intent is to cause no delays in construction due to unavailability of cable, and also to make available an infrastructure that can supply cable locally to WSF post-Contract.

87.12.3 Cable Routing, Penetrations, and Hangers

All cable shall be run as directly as practicable, consistent with adequate ventilation of the cable wireways, avoidance of hazardous or otherwise undesirable locations and to reduce Vessel weight.

Cables connected to an emergency source of power shall not be run along or attached to the machinery casing, transit machinery spaces, uptakes, or the Food Vending areas except those cables serving equipment located in those spaces.

Extreme care shall be exercised to ensure that no wireways or cables cross or otherwise interfere with soft patches in the engineering spaces. These areas shall be kept clear of all permanently installed wireways, individual wire runs, lighting fixtures, junction boxes, etc., to facilitate the rapid removal and reinstallation of major propulsion system components and equipment which cannot be transported through the doors and hatches. The only exception to this shall be the lighting fixtures subject to the conditions stated in Section 92 of the Technical Specification and wiring going to the units located below the soft patch areas which would be removed and thus would require removal of the wiring anyway. The goal of this requirement is to facilitate the removal and reinstallation of

major machinery components without having to disconnect or remove permanently installed electrical equipment or wiring.

Unless demonstrably impractical, cables shall not be installed adjacent to piping systems, machinery, or other sources from which leaks or condensation drips may occur. When such proximity is unavoidable, shielding manufactured of no less than USSG No. 14 gauge galvanized sheet metal shall be provided. The shielding shall be sectioned in lengths convenient for removal by hand. Where practicable, cables shall not be exposed to engine exhaust manifolds, exhaust piping, or other such sources of extreme heat. Where this is demonstrably impractical, appropriate insulated heat shields shall be provided.

Unless demonstrably impractical, all cables to weather deck mounted fixtures shall be installed on the inside surface of the structure supporting the fixtures. If it is necessary to install cables on exterior surfaces in areas that are accessible to the public, they shall be fitted with a sheet metal cover from the deck level to no less than 7 feet - 6 inches above the deck, or to the fixture being served, which ever is the lesser height. The covers shall be manufactured of no less than USSG No. 14 gauge galvanized sheet metal attached in a manner that does not require destruction of, or excessive damage to, the cover for removal to inspect or service the cable. The shielding shall be sectioned in lengths convenient for removal by hand. All coverings shall be finished to match the surrounding decor. See Sections 19 and 25 of the Technical Specification.

In high traffic areas, or other areas in the opinion of the WSF Representative where cables may be damaged by door openings, equipment being moved, hand cart traffic, and other similar circumstances, removable kick protection shall be provided to a height of no less than twenty-four (24) inches above the deck. Less susceptible areas shall have kick protection to a height of no less than nine (9) inches. All cable protection shall be sufficient to protect the cable from any reasonable source of damage. All kick guards shall have drain holes near deck level.

Where an MCT or MCP is required for a deck penetration, a watertight riser box shall be provided. The riser box shall be at least four (4) inches high, as measured from the top of the finished deck to the top of the riser box.

Multi-cable transits required for deck penetrations shall be provided with kick guards which are at least nine (9) inches high in the weather and six (6) inches high elsewhere, measured from the top of the deck or deck covering to the top of the kick guard.

Cables which penetrate weather-tight, water-tight, or drip proof enclosures or fixture, and all power distribution panels shall be provided with waterproof cable/cord grips. BX cable/cord grips may only be used for cable penetrations through the bottom of power

distribution panels that are flush mounted NEMA 1, located in dry spaces, Passenger Deck and above.

Cable supplied from the emergency switchboard shall be connected in accordance with the requirements of 46 CFR §112.

Power and lighting cables shall be double banked in bunches of six (6). Unless specifically directed otherwise in the Technical Specification, cable segregation requirements as conceptually prescribed in WSF Drawing. No. 8200W-138-90-3 shall be adhered to, and cables shall be double banked except under unique and specific conditions with the express, written approval of the WSF Representative. IC cable **shall not** be double-banked with power or lighting cable.

NOTE: "Double-banked" is defined for this Contract as "two (2) layers of similarly sized cable, one over the other." Power and lighting cables **shall not** be double banked together.

Critical circuits shall be segregated as recommended by the associated equipment manufacturer and as required by 46 CFR.

Unless specifically directed otherwise in the Technical Specification, the cable way (wireway) support system, on overheads, shall be RESEARCH TOOL & DIE WORKS, or equal, inverted "TEE" type, or "TRAPEZE" type with exceptions in conceptual accordance with WSF Drawing. No. 8200W-138-90-03. Bulkhead mounted cable ways shall be new "TRAPEZE" type all sized for 20-percent (20%) growth in quantity and weight of cables, unless otherwise specified under specific equipment installation Sections of this Technical Specification. Cable way tiers shall be spaced four (4) inches on center. Spacing of no less than 1½ cable diameters (based on the largest cable on a tier or cable hanger) is acceptable only in cases where the four (4) inch spacing cannot be achieved. Wireway tiers shall be bolted to the down comers, welding **shall not** be acceptable under any conditions.

Wireway and lighting fixture down comers **shall not** be welded directly to the underside of the Vehicle Deck. They shall be attached to stiffeners or flat bar run between stiffeners. All welding of down comers and adapters shall be 100-percent (100%).

Cables shall not be installed or attached to gratings or walkways in the Machinery Spaces, bilges, or other areas where they may be subject to oil damage. When it is absolutely necessary to run cables under gratings or walkways, they shall be installed on the underside of drip-proof pans or run through liquid tight, flex conduit. Metal pans shall be manufactured of no less than USSG No. 14 gauge galvanized sheet metal. If

cables are run through conduit, the cable ampacity shall be de-rated in accordance with the National Electric Code (NEC) or the fill ratios shall not be exceeded.

Power and lighting cables shall be run in separate wireways from interior communication, alarm, and other cables affected by EMI to the greatest extent practical.

1. "Interior" cable hanger materials shall be of steel with a corrosion resistant finish. Weld and fabrication areas at hangers, studs, down comers, cross tiers, and other hardware shall be prepared to a SSPC SP-3, "*Power Tool Cleaning*" or grit blasted to SSPC-SP 6, "*Commercial Blast Cleaning*", as defined in Section 14 of the Technical Specification, and primed immediately after welding, and painted in accordance with Section 14 of the Technical Specification **before** the installation of any cables. Finish coats of paint which are required by Section 14 of the Technical Specification shall be applied after all Work on the wireway has been completed. All "interior" bolts, studs, nuts, and washers shall be CAD plated.

2. All "exterior" cable hanger materials shall be of steel with a corrosion resistant finish. All exterior hanger studs, extenders, and clips shall be of Type 316L stainless steel with ANSI Grade Type 316, or better, stainless steel nuts, bolts, and washers. Weld and fabrication areas at hangers, studs, down comers, cross tiers, and other hardware shall be prepared to SSPC-SP 3, "*Power Tool Cleaning*" or grit blasted to SSPC-SP 6, "*Commercial Blast Cleaning*", as defined in Section 14 of the Technical Specification, primed immediately after welding, and painted in accordance with Section 14 of the Technical Specification **before** the installation of any cables. Finish coats of paint which are required by Section 14 of the Technical Specification shall be applied after all Work on the wireway has been completed.

NOTE: "Exterior" encompasses those areas which can be affected by salt spray or rain, either falling or wind blown. The entirety of the Vehicle Decks (including Tunnel area), Machinery Casing exteriors, Pickleforks, Picklefork decks, the underside of the Passenger Deck, Sun Deck, interior of the Sun Deck Passenger Lounges, and Sun Deck and Navigational Bridge Deck Housetops and masts shall also be considered exterior surfaces.

All cables installed in horizontal wireways shall be arranged so that if the cable retention device fails, the cable will remain supported by the hangers.

NOTE: For purposes of this Contract requirement, "exterior" and "weather" areas include Lower Vehicle Deck (outboard and Tunnel), Upper Vehicle Decks, Passenger Deck Exterior and Pickleforks, Sun Deck (except inside

superstructure), and Sun Deck, interior of the Sun Deck Passenger Lounges, and Sun Deck and Navigational Bridge Deck Housetops and masts.

All wireway down comers and hangers shall receive an initial coat of primer and paint after hot work is completed and prior to attaching cross tiers and hardware. Cross tiers shall receive the same treatment prior to installation.

Main wireway hangers shall be spaced no more than eighteen (18) inches apart on centers. RESEARCH TOOL & DIE WORKS, or equal, tubular type and crimp type hangers for local wireways shall be spaced no more than fifteen (15) inches for cables ¾ inch or larger in diameter, and no more than twelve (12) inches for cables less than ¾ inch in diameter.

For local runs, installation of RESEARCH TOOL & DIE WORKS, or equal, crimp type hangers shall orient the radiused, or solid portion of the crimp forward, down, or outboard. The use of WESSLER pan-type hangers **is prohibited**. The use of adhesive backed cable retainers **is prohibited**. The use of quad hangers (butterfly) **is prohibited**.

All cable banding, interior and exterior, shall be stainless steel, a minimum of ⅝ inch wide × 0.015 inch thick. Unless directed otherwise in the Technical Specification, cable shall be installed in accordance with Reference (87F) Section 25, (see WSF Drawing. No. 8200W-138-90-3 for conceptual illustration), and 46 CFR §111. Non-metallic cable retention devices **will not** be allowed.

Install hard flexible channel rubber between banding material and cable in all wireways.

There shall be no penetrations made in structural members, not including bulkhead approved multiple cable transits, without the prior, specific, written approval of the WSF Representative.

For WSF Fleet-wide Standardization purposes, no more than two (2) stuffing tubes shall be used in any location, except for Sun Deck and Navigation Bridge Deck or areas exposed to UV radiation, as approved by the WSF Representative on a "case-by-case" basis, where cable transits would not be appropriate. In locations where three (3) or more cables penetrate a bulkhead or deck at the same location, multiple cable transits (MCTs or MCPs) manufactured by NELSON or MCT BRATTBERG shall be utilized in lieu of stuffing tube nests. In locations where stuffing tubes are used, the clear distance between adjacent stuffing tubes shall be a minimum of one and one-half (1½) diameters of the larger of the stuffing tubes under consideration. **Poured type cable transits are not acceptable.**

NOTE: The use of sealers on MCT and MCP block contacts during assembly **will not be acceptable** except in the case of armored cable to block contacts.

Radius corner banded stress relieved MCTs manufactured by NELSON or MCT BRATTBERG shall be provided in decks and bulkheads subjected to high degrees of stress.

Unless otherwise specified by installation Sections of the Technical Specification, multiple cable transits shall be provided with a minimum of 20-percent (20%) spare capacity for cables of a similar size (provide a minimum of 30-percent (30%) spare capacity for EOS and Pilothouse console MCTs/MCPs), and in no case less than one (1) spare. These spare insert modules shall allow for a cable as large as the largest cable installed in the transit.

The use of removable insert (wrap) type MCT/MCP blocks is prohibited and shall only be allowed if approved in writing, on a "case-by-case" basis, by the WSF Representative.

Preparation, fit up, and weld out for transits shall meet the written requirements of the manufacturer to prevent possible transit distortion.

In locations where MCTs or MCPs are used such as Pilothouse areas for mast cabling, the cabling for the mast shall be run through MCTs and MCPs located under the Pilothouse apron so as not be exposed to the elements.

Unless directed otherwise in the Technical Specification, all cables and transits shall be conceptually installed in accordance with WSF Drawing. No. 8200W-138-90-3, packed, and sealed exactly as recommended by the transit manufacturer. **No waiver of this requirement will be considered**.

For required testing of MCTs, MCPs and Stuffing Tubes see Section 101 of the Technical Specification.

Provide stuffing tubes for deck penetrations with kick pipes that are at least ten (10) inches high in the weather and six (6) inches high at all other locations. The other side shall extend ½ inch beyond any thermal or acoustic insulation in accordance with NVIC – 9-97, *Guide to Structural Fire Protection*.

NOTE: The above requirement is as measured from the top of the finished deck, to the top of the stuffing tube.

Unless directed otherwise in the Technical Specification, cable penetrations through bulkheads, decks, and beams shall conceptually comply with WSF Drawing No. 8200W-138-90-3, Authoritative Agency requirements, and the following:

1. All new and existing openings in bulkheads, decks, platforms, gratings, and/or beams used as cable penetrations, and which do not require multiple cable transits or stuffing tubes, shall have a continuously welded steel or aluminum collar. Rat holes (snipes) or limber holes **shall not** be used for cable routing. The collar thickness shall be equal to or greater than the material removed. The length of the collar is determined by the location. In general, the collar shall have the same quantity of material as that which is removed. In areas of insulation, the collar shall extend ¼ inch beyond the finished surface of the insulation, but in no case shall the collar be less than three (3) inches in length. Particular care shall be exercised to ensure compliance with this requirement for cable penetrations through switchboard platforms and other locations throughout the Vessel. Where collars larger than three (3) inches in diameter penetrate non-watertight bulkheads, decks and/or platforms, non-foam, USCG approved, fire stop putty shall be installed with sheet metal retainers installed to prevent the putty from falling out. Collars less than three (3) inches in diameter are required to only be packed with USCG approved fire stop putty.

2. On cable penetrations through fire rated boundaries the cable exiting the bulkhead penetration shall be treated with NELSON FSC™ Fire Protective Coating, or equal. The coating shall be applied in accordance with manufacturer's recommendations, and USCG requirements.

3. Cable openings in bulkheads not requiring stuffing tubes or multi-cable transits and are not required to have insulation of any kind shall have a collar continuously welded all around the edge of the opening. This collar shall be a minimum of three (3) inches wide and will be required regardless of the thickness of the flange or plate being penetrated.

Exercise extreme care during installation of cable, wire, and other equipment that the external jacket of the cable and/or wire is not nicked, scraped, abraded, cut, burned, or otherwise damaged. Cable and/or wire that is damaged in any way during the Work shall be replaced in its entirety by the Contractor, at no additional expense to WSF.

Splices **will not** be permitted to repair cable damaged or to extend cables during the Work.

Each electrical device shall be directly connected to the circuit breaker protecting the equipment unless a receptacle is specifically called for by the Technical Specification.

Cable in Officers' and Crew accommodation block spaces, Dayrooms, and public accommodations, including all sanitary spaces, shall be concealed. Where bulkhead construction makes concealment demonstrably impractical, wiring shall be neatly formed and installed on the surface in a craftsman-like manner, paying particular attention to the esthetics of the installation and protection of the cable.

87.12.4 Cable Identification

Identify each cable by its circuit number and cable type with a raised-letter embossed aluminum tag wherever it enters an enclosure of any type, or penetrates a deck or bulkhead. Cables shall have identification labels on each side of deck or bulkhead penetrations and at any other location where both sides of the penetration are not readily visible from a single location for cable tracing purposes.

Cable tags shall be covered while the space in which they are located is being painted or be installed after the painting has been completed. Care shall be taken that the correct cable tag is installed on each cable and in every location where required. The Contractor shall be wholly responsible for any expense incurred as the result of improper cable tag installation and for correction of any improperly installed cable tags.

Assign a unique cable number to each separate piece of cable on the Vessel.

For circuits that branch or are connected at junction boxes or in lighting fixtures, the basic cable number shall remain the same throughout the circuit. A bracketed three-digit number (×××) identifier shall be appended to each individual cable or wire starting with the lowest number at the power or signal source and increasing to the farthest load.

NOTE: The cable and circuit identification system depicted in the Contractor's (Electrical One-Line Diagram) shall be used. Use of any other system of cable and circuit identification will be cause for immediate rejection.

Wiring identification floaters shall be white polyolefin with permanent "BLACK" typewritten lettering. For WSF Fleet-wide Standardization purposes, floaters shall be RAYCHEM-TMS (Terminal Marker System). ***Hand written or lettered floaters shall not be acceptable*** and, if installed, shall be removed and replaced wholly at the expense of the Contractor. The correct circuit number shall be indicated on one side of each floater; on the obverse side, a three (3) part terminal identification number with each of the parts separated by a slash (/) shall be provided. The terminal identification number shall consist of the termination block and the termination point identification, the opposite end termination block and termination point identification, and the individual conductor identifier within the cable. (i.e., TB-1(4)/TB-3(4)/16). This includes spare wiring and jumpers, which shall also be fully identified.

After all three-phase cables have been phase matched, cables that are 23,000 circular mils and larger shall be provided with tight fitting, phase-matching color coded markers at each end in order that phase conductors may be easily identified. The markers may be heat-shrink vinyl or no less than two (2) full wraps of ½ inch wide plastic tape. If tape is used for phase identification clear heat shrink tubing shall be installed over the tape to prevent its accidental removal. Phases shall be coded as set forth in **TABLE 87-1** below. Ground conductors, regardless of circular-mil size shall be marked "GREEN"

For Direct Current (DC) circuits, shall be marked as set forth in **TABLE 87-1** below.

TABLE 87-1

CABLE CIRCUIT IDENTIFICATION COLOR CODING

Wire Type	Phase Color Code	Ground Conductor
3-Phase, 3-Wire	**A** - "BLACK", **B** - "RED", **C** - "WHITE"	"GREEN"
3-Phase, 4-wire	**A** - "BLACK", **B** - "RED", **C** - "BLUE", with a "WHITE" neutral	"GREEN"
Single-Phase, 2-wire	one (1) - "BLACK", two (2) - "WHITE"	"GREEN"
Direct Current (DC)	Positive - "BLACK", Negative - "WHITE"	"GREEN"

Once established, the color coding system shall remain consistent throughout all electrical systems installed in all Vessels.

The Contractor shall seal new, large cables greater than 3/0 AWG (15,000 circular mils) with RAYCHEM heat shrinkable boots. Cables with individual conductors of greater than 150,000 circular mils and all other cables serving distribution panels shall have the individual conductors fitted with tight fitting clear vinyl tubing the length of the exposed conductors and sealed with heat shrink tubing with internal adhesive at both the crotch and cable ends of each conductor. On multiple conductor cables, the end shall be fitted

with a heat shrinkable crotch boot with internal adhesive. Color coding of cables shall be provided as described above. Lugs shall be appropriately sized for the conductor, silver plated, closed end crimp style, of the proper style and type shall be utilized in making all Generator, Switch Board, Distribution Panel and ABTs bus connections.

Cables 23,000 circular mils and larger, shall have both ends sealed with a flame resistant, waterproof sealer prior to final termination, see above for lug requirements. Cables, which penetrate weather-tight, water-tight, or drip-proof enclosures or fixtures, and all power distribution panels, from the top or side, shall be provided with waterproof cable/cord grips. BX cable/cord grips may only be used for cable penetrations through the bottom of power distribution panels located in dry spaces above the Passenger Decks.

Cables penetrating enclosures, fixtures, distribution panels, switchboards, and other similar items and devices, shall have no less than ⅛ inch, nor more than ⅜ inch of the impervious cable jacket extending into any enclosures, except as required for the installation of heat-shrinkable boots, when approved on a "case-by-case" basis by the WSF Representative, and then only enough for the installation of the subject boot. Shielded cables, either single or multi-pair construction, shall have the outer jacket removed and each pair shall be sleeved to within four (4) inches of the termination. Sleeving shall be clear and tight fitting for each shielded pair. All shield and drain wires shall be sleeved from brake-out to point of termination, no bare conductors shell be exposed.

87.13 FIBER OPTICS INSTALLATION

Personnel installing and testing optic cable and terminations shall possess demonstratable previous experience with fiber optic cable installations of the type required by the Contract and Technical Specification.

All fiber optic cables shall be terminated with "SC" style terminations in accordance with MIL-SPEC MIL-C-83522. Cables and terminations shall be tested in accordance with the *FIBER OPTIC CABLE INSTALLATION TESTING* Subsection in Section 101 of the Technical Specification. Fiber optic cables shall be selected in accordance with MIL-PRF-85045F, UL 1651-1997, or IEC 60794-2. These cables shall be low smoke, flame retardant, and meet IEEE Std. 1202-1991. Cable bend radiuses shall not be less than cable manufactures recommendations.

Unless specified differently in specific Sections of the Technical Specification, all new fiber optic cable installations, shall be tested as set forth in the FIBER OPTICS INSTALLATION Subsection in Section 101 of the Technical Specification.

87.14 SPARE PARTS AND INSTRUCTION MANUALS

Provide a list of recommended spare parts and special tools, for those items which are Contractor furnished, together with parts lists and instruction manuals necessary to maintain and service provided equipment and accessories in accordance with the requirements of Sections 86 and 100 of the Technical Specification.

87.15 TESTS, TRIALS, AND INSPECTIONS

Tests and/or Trials shall be in accordance with Section 101 of the Technical Specification.

Inspections shall be performed as defined in this Section and in Sections 1 and 2 of the Technical Specification.

87.16 PHASE II TECHNICAL PROPOSAL REQUIREMENTS

The deliverables required by Section 100 of the Technical Specification and the Authoritative Agencies, shall be provided during the Phase II Technical Proposal stage of Work in accordance with the requirements of Section 100 of the Technical Specification.

See Section 100 of the Technical Specification for additional requirements regarding technical documentation.

87.17 PHASE III DETAIL DESIGN AND CONSTRUCTION REQUIREMENTS

The following deliverables, in addition to other deliverables required by Section 100 of the Technical Specification and the Authoritative Agencies, shall be provided during the Phase III Detail Design stage of Work in accordance with the requirements of Section 100 of the Technical Specification, to define the normal and emergency power systems and the lighting and power panels installed throughout the Vessel:

A. Cable Schedule and Data Summary

B. Cable Wire Termination List; Data Summary

C. Cable Data Base; Master File

D. Phase Balancing Calculations

E. Coordinated Trip Analysis

F. Harmonic Interference Analysis

See Section 100 of the Technical Specification for additional requirements regarding technical documentation.

(END OF SECTION)